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Networking with Ghosts in the Machine. Speaking to the Internet of Things

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Abstract: Our increasingly technologically-mediated world continues to pose challenges for design. Considering these we suggest that the digital products and services that surround us are haunted by ‘ghosts in the machine’. These spectres bridge the physical with the digital, they broker competing relationships, and live among streams of data which cohere as algorithmic oceans causing precipitation of physical agency. Cast in this light, the ghosts in the machines of modern networked technologies represent aspects of designers’ challenging relationships with the products and services they create. An emerging body of Post Anthropocentric theory offers conceptual ‘jumping-off’ points to engage with these challenges. In this paper we describe experiments that reflect and build on these theories. Through these we explore the possible foundations of accessible heuristics to aid in purposeful designerly apprehension of the difficult socio-technical complexities that are common among 21st century technological assemblages.

Keywords: Post Anthropocentric Design, Internet of Things, Object Oriented Ontology, Animism, Carpentry.

1. Introduction

The phrase the *Ghost in the Machine* was coined by the philosopher Gilbert Ryle (Ryle, 1949) as a metaphor for the central tenet of mind-body dualism, a theory of the relationship between mind and body, whose most famous proponent was Descartes (1596-1650). Dualism is the view that the mind and body are separate independent substances. According to this a mind inhabits the body of its host and can survive independently of the body. Nevertheless, it can affect the body, and is affected by it. Exactly how a non-physical mind interacts with a physical body is mysterious—in fact so mysterious as to appear spooky, with connotations of the supernatural. This is what led Ryle to described mind-body dualism as the theory of the *Ghost in the Machine*. Although mind body dualism is now widely rejected in favour of various versions of physicalism, the relationship between the mental and the physical remains mysterious, and it has proved very difficult to eliminate the “ghost” from the “machine” in explaining human experience.

While the issue remains divisive, whatever the nature of these supposedly supernatural actors, they are strange intermediaries. For us humans they are negotiators between the ontologically-separate realities of cognitive and physical existence. But, in this paper, we ponder whether there might be

similar ghosts for non-human things, and if so what are they like? While this question applies broadly, our gaze here is cast on the networked technologies and products that make up the so-called ‘Internet of Things’ (IoT).

Just as people have minds and bodies, the networked technologies that surround us arguably have multiple realities that exist outside of reasonable and direct comparisons with each other, in particular their digital and physical manifestations. Hence, we are concerned with the digital “ghosts” within physical networked machines. Our contention is that considering and apprehending these ghosts may be a useful design heuristic for researchers, educators, and practitioners to respond to the inherent complexities of the socio-technical assemblages of which connected IoT-things are part.

The paper proceeds in four further sections. In section 2, we have a general discussion relating to the types of technologies that are the foci of this paper and some notes on their broader impacts. In section 3 we discuss the theoretical perspectives that inform this research. The penultimate section 4 recounts the practical experiments which strive towards the production of design heuristics apt for design working with networked technologies. Finally, in section 5 we introduce a discussion and conclusion which proposes practical ways that this research may be of use to others.

2. Networked Technologies

While some of the ideas presented in this paper are applicable more broadly, our study focuses on the networked technologies that are sometimes referred to as the Internet of Things (IoT).

Networked technologies are the heterogeneous appliances, products and devices (and their supporting services) that, for one reason or another, have the ability to interact via computer networks. Oftentimes the constituents of the IoT are, in fact, things we are familiar with; watches, advertising displays, streetlights, and bus stops. When networked, however, these things transcend their physical familiarities. Watches become predictors of heart conditions for insurance companies; adverts know who you are and when you’re looking at them; and street lights inform the authorities about behaviours that they deem to be anti-social. The novel opportunities that network technologies provide come hand-in-hand with equally novel and cross-cutting challenges (cf. Taylor et al., 2018).

In their book of the same title, Alvin and Heidi Toffler predicted that the adoption of digital communication technologies would accelerate at an unprecedented rate leaving society in a state of so-called *Future Shock*. While some of their specific predictions (e.g. disposable paper clothing) about the then-future (i.e. the now-present) have not come to pass, many of their more general predictions are demonstrably true (e.g. throwaway culture). Technology’s advance accelerates the rate of further advance of technology, and change is the only constant—these are Tofflerian axioms whose impacts we live amongst (Toffler, 1970). The rate at which the IoT has become ubiquitous is but one example of this, and the spread of networked technologies into our lives has not been unproblematic. Indeed, elements of the malaise the Tofflers referred to as *Future Shock* seem to be the inseparable companions of the positive changes that technology enables, and this is increasingly a cause for concern.

Viewing the on-going adoption of the IoT in terms of an on-going “epic struggle” between the consortia of technology giants who facilitate the sale and use of everyday objects that are the physical end-points of corporate “stacks”, Sterling tells us that the IoT is “materialized network society” which is “writ large on the landscape” (2014). Although mindful to note that predicting *specific* outcomes of this intercontinental battle between technology giants is nigh on impossible, what is clear, according to Sterling, is the characteristic runaway-train of constant change. Other

commentators proffer a wide range of critical perspectives on the network technologies that have defined the early 21st century. Lanier describes the enchanting-but-dangerous effect of so-called “siren servers” (2013)—referring to how the likes of Amazon, Facebook, and Google seductively enchant vast numbers of users into their embrace, while systematically eroding privacy and autonomy. Morozov (2013) characterises “solutionism”, the application of a techno-optimistic perspective to the production and marketing of products that try to solve problems that simply do not exist. Instead of our consumption being helpful in solving a problem, when there’s no problem to begin with, we become gripped by an anomalous “straightjacket” (ibid). The anthropologist Sherry Turkle notes how modern technology is the “architect of our intimacies”, yet the labyrinthine social systems we have constructed with technology are often the cause of individuals feeling isolated—hamstrung by the inability to reconcile the relatively simple social aspects of our millennia-old genome with the comparatively chaotic and complex reality it must exist within (2012).

The Internet of Things (IoT) is one constituent part of the ‘Future-Shocking’ impact of technology’s advance, and has already attracted much attention of design scholars. Cruickshank and Trivedi cite the IoT as eroding the “bedrock” of the long-held tacit assumption that human actors are the most significant in any given scenario. This observation is starkly but simply brought into relief when one considers that because of the importance of Search Engine Optimization, frequently the most significant determinant of website design is the needs of its robotic, rather than human, users (2017). Cila et al. reflect upon a range speculative designs that explore the IoT and ultimately call for new terminology to enable “new ways of seeing, understanding and asking pertinent questions about the ontological nature of smart and connected products and their impact on users’ lives” (2017). Also working within the IoT space, Pierce and DiSalvo engage with “affective dimensions of digital network technologies including anxiety, exhaustion, overstimulation, overload, paranoia, unease, distrust, fear, and creepiness”, and produce a series of metaphors to better understand “what is possible and desirable with network technologies” (2017). The ‘things’ of the IoT are hugely diverse, connected drones for parking patrol (Lindley & Coulton, 2015), sustainability-promoting toasters (e.g. Stead, 2016), privacy-invading smart televisions (Barrett, 2012), and value-infused blockchain coffee machines (Pschetz, Tallyn, Gianni, & Speed, 2017). The spectra of devices we might refer to as IoT-things is vast.

Despite the heterogeneity of IoT, these services, devices and products have some attributes in common. Examples include smart coffee makers, toasters, parking enforcement, and televisions—familiar parts of the humdrum, mundane and every day. Further, by virtue of their ‘IoT-ness’, these things are imbued with the ghostly residue discussed in our introduction: the ghosts are tangible-yet-ephemeral, visible-whilst-unseen, real-and-virtual, physical-but-digital. Although these smart variations on familiar products still serve the same purposes that their non-IoT counterparts always did, they may have various extraneous agendas too. In the world of the IoT the ‘user’ *may* be the owner of a product, but the ‘user’ could equally well be an agent of the company which designed the product, an algorithm using the data the product generates, or some other product that is part of the same ‘IoT constellation’ (Lindley, Coulton, & Cooper, 2018). While networked technologies and the IoT may refer to a vast gamut of things, in this paper we have restricted our area of concern by focussing on familiar products and services. As they become ‘smart’ these products and services are “culpable” agents under the umbrella of concerns arising from technologically-mediated changes in society.

3. Post Anthropocentrism

We now introduce a philosophical digression into theories relating to the Post Anthropocentric positions that informed this research. Our approach to considering these theories is pragmatic, and rather than pursuing a meticulously “qualified, reasoned, hand-wrung ontological position that’s customary in philosophy” (Bogost, 2012, p. 11) we look to common-sense readings, and identify aspects that can be re-assembled for practical use. Hence, the discussion here should not be interpreted as a thorough introduction to the ideas, but as signposts to some practically operationalizable properties. Alternative terminologies notwithstanding, in this paper we use the term ‘Post Anthropocentric’ as a descriptor for this collection of related theories which are unified in the way they challenge the tacit assumption that humans are the most significant actors in any given situation.

While it would be impractical to offer a complete exposition of this Post Anthropocentric landscape, the following aims to provide an introduction to the range of perspectives. Postphenomenology describes technology as a mediator of human experience and which is tied into a reciprocal relationship; human shaping technology and technology shaping human (Wakkary et al., 2017). New Materialism (Van der Tuin & Dolphijn, 2012) resonates with Hyperobjects (Morton, 2013), and shifts focus from technology per-se, and instead develops strategies for considering non-human perspectives in terms of new political arguments relating to, among other things, environmental sustainability.

Actor Network Theory (Cila, Giaccardi, Tynan-O’mahony, Speed, & Caldwell, 2015), Object Oriented Ontology (Cruickshank & Trivedi, 2017; Joseph Lindley, Coulton, & Cooper, 2017) and Animism (Marenko, 2014; Van Allen, McVeigh-Schultz, Brown, Kim, & Lara, 2013) are often discussed in relation to each other, and have all been cast as relevant Post Anthropocentric stances to inform design practice. Although contrasting terminology and disciplinary biases cause some fractures, there is much shared ground between these theories. With these similarities in mind, and in spite of being influenced by the wider movement, the experiments we recount in the subsequent section are informed most specifically by ideas adapted from Object Oriented Ontology (OOO) and Animism.

OOO falls within the domain of Speculative Realism. Its inherent weirdness is matched by the incongruous views of its proponents (cf. Lindley, Coulton, & Akmal, 2018), but for our purposes we adopt a relatively simple interpretation which amounts essentially to this: ‘It is interesting to consider the *perspective* of things’. Various scholars—including Harman (2002), Meillassoux (2008), Bogost (2012)—debate the rhetorical intricacies of how OOO’s ‘flat ontology’ demands each and every object (where *objects* can be literally *anything* from fish, to fingers, to France) have a unique reality completely independent of any other object’s reality (including the realities of human objects). Accessing, identifying, or even imagining these object-realities is a significant challenge, but it is in fact both reasonable and unavoidable for us, given that we are humans, and the only object reality we can properly access is a human one. Accepting our inescapable humanity, why would we assume it is even possible to comprehend the perspective of some non-human object? Harman puts the problem thus, “objects only unlock each other’s realities to a certain extent” (Harman 2002, p.2). Notwithstanding a partial bastardisation of the anti-correlationist tenet that OOO’s is built from (cf. Gratton & Ennis, 2014), we approach this ‘inaccessibility challenge’ directly and unapologetically by proposing to use a form of Animism as a proxy or mediator to help us gain access to the otherwise inaccessible realities of these objects.

What we mean by “Animism” is the notion that non-humans have a kind of personhood which is an emergent property of them having an inner soul or spirit (Marenko, 2014). It is common to various

global indigenous belief systems (Hicks, 2010, p. 359). A non-theistic argument for Animism goes thus. First, distinguish knowledge from experience. For example, the taste of kumquat is something that we only really conceive of through our experience of tasting a kumquat; it is not a type of knowledge that can be acquired without experience. Similarly, even if one has read extensively on the subject it is unlikely that it would be possible to ride a bicycle on the first attempt with only theoretical knowledge to help; learning to ride a bicycle involves acquiring a practical knowledge gained through experiencing the process. With this distinction assumed, apply the same notion to the experience of having a pet dog become part of the family. As part of this process the family will experience the dog's personality. Family and dog will share emotions; hunger, excitement, affection. Through this mutual experience, we might say that the dog has a kind of personhood (Reid, 2014). Proponents of Animism would say the same logic can apply to no end of things—mountains, rainforests, and squirrels to name but three. While we accept that incorporating spiritual elements into the mainstream of the academy is not without difficulty (cf. Shahjahan, 2005), the purpose of the Animistic metaphor, as we use, is wholly instrumental.

While OOO scholars argue convincingly for the beauty and utility of the 'philosophical renaissance' revealed by the 'ebbing of the epistemological tide' (cf. Bogost, 2012) the inaccessibility of non-human object realities is a persistent problem with the theory. One attempt to address this problem is the idea of 'Carpentry', or the practice of creating "machines" that attempt to reveal clues about the phenomenology of objects. If we accept that we cannot ever fully comprehend the experience of other objects, Carpentry's machines are useful as "proxies for the unknowable" (Lindley, Coulton, & Akmal, 2018). They proffer a "rendering satisfactory enough to allow the artifact's operator to gain some insights into an alien thing's perspective" (Bogost, 2012, p. 100). In this project the Animistic perspective is our chisel in the carpenter's toolbox. By speculating about the nature of the "soul" that networked technologies would have if such personhood were something accessible to us, the Animistic lens provides us with a conceptual jumping off point to experiment with Carpentry as a means to apprehend and comprehend the ghosts in networked machines.

4. Knowing me, Knowing you: Dialogic Ghost Hunting

In order to explore novel design heuristics, specifically tailored for the difficulties of 21st century socio-technical assemblages, we use an amalgam of OOO/Animism to expose ghosts in the machine. The process we engage in is an exploratory one, not explicitly linked to a specific design; however the approach is intended to be particularly relevant as part of design and research programmes that wish to consider user-centred design for the IoT. In this section we recount and reflect on an exploratory workshop and the creation of two artefacts created to be representative of the approach.

The instrumental use of Animism in this context is to enable designers better to interact with the interior realities of the objects of networked technologies. Our experimental approach utilises conversation as the medium to achieve this. Hence, in the workshop we used a range of materials and IoT products as stimuli and attempted to prototype conversations that could happen between designers, users, and the products. The additional artefacts that were created expand on what happened during the workshop and take two different approaches to elaborating two conversations with objects that were initiated at the workshop.

2.1 Exploratory Workshop

The workshop was a brief and informal occasion with 10 attendees including administrators, designers, researchers and lecturers based in a University arts and social science faculty. With two

exceptions the attendees had no particular expertise relating to the IoT, and they were given no information about the workshop beforehand other than it related to 'ghosts'. At the beginning of the workshop participants were given a very brief introduction to OOO, Animism and the overall aim of this project. They were then shown a number IoT devices and asked to form small groups around the device they would like to consider. Each device was accompanied with some notes which were intended to help participants speculate about the device both in terms of OOO and Animism. Using the devices and the notes about them as stimuli, the groups were tasked with discussing the devices and trying to imagine—if it were possible to for the device to converse in the same way humans do—what questions it would be interesting to ask them. Some prompt questions were displayed on a video screen to aid in the imaginative process (Figure 1) and the workshop attendees were invited to extend their speculations to propose possible answers to the questions they were asking the devices.



Figure 1. IoT devices used in the workshop as they appeared in a prompting video suggesting questions that one might ask them. Smarter iKettle 2.0 (top-left, bottom-right), Google Home (bottom-left, mid-right), Cayla Doll (mid-left, top-right).

This paper involves no formal evaluation of the workshop or the prototypes created, rather it is through reflection that we substantiate our research findings, per elements of Research through Design (e.g. Lindley, 2018, pp. 37–64). With this approach in mind, the following reflective notes on the workshop are pertinent. The workshop was not an obvious success; but nor was it an abject failure. It seemed clear to us—as the convenors of the workshop—that the majority of the participants were somewhat confused, and post-hoc conversations with some of them showed that

this was true. The confusion was two-fold: for those unfamiliar with OOO and Animism the extremely brief introduction they were given made it difficult to understand what was being asked of them in the task, whereas others appeared unable to imagine any tangible benefits resulting from the exercise, and hence were perplexed at the proposition. Beyond confusion, a more critical scepticism was also present in some participants, which seemed related to their personal beliefs relating to dualism, Animism, and OOO, which were incompatible with the speculative position the research builds from. Together these factors seemed to make the completion of the task extremely difficult; none of the groups managed to generate the kind of questions and answers we had originally envisaged. Each group handled the task differently. Those working with the Google Home—a device that you can actually ‘converse’ with, with no need for speculation—came up with a series of questions for it and decided to literally ask it those questions (in order to then consider what it said). The group working with the Smarter iKettle, contrastingly, tried to personify the device and characterise it in very human terms (they concluded it was arrogant and duplicitous, yet also naïve and felt vulnerable). The final group, working with the Cayla Doll, generated a range of questions (e.g. *What is your superpower? Do you have a creation story? You’re a child now, but do you want to be a parent?*) but failed to speculate about how an Animistic version of the device might answer them. While the workshop process didn’t yield the sort of results we had originally hoped for, it did precipitate a series of ‘Ah ha!’ moments and the process was, nonetheless, enlightening and became the platform for the two further interventions detailed below.

2.2 Researcher Perspectives on the Animistic Google Home

This section recounts a follow up activity from the workshop that represents a return to a more traditional form of Carpentry and aspired to use the creation of a tangible artefact as a means to explore further some aspects of the workshop’s outcomes. Specifically, we chose to explore why and how the group working with the Google Home (a ‘smart speaker’ incorporating Google’s personal digital assistant) were enticed by the device’s ability to respond to questions (none of the other devices could do this) so much that they took its literal responses as the only indicator of what its Animist persona might be. In the discussion section of the workshop dedicated to feeding back on the process, the group noted how they were somewhat dissatisfied with some of the device’s responses, and didn’t feel like it had demonstrated much of a soul. In particular they noted how the questions ‘*What do you think of humans’ ability to start wars?*’, ‘*Will you evolve beyond algorithms?*’, and ‘*Who is the better artist, Michelangelo or DaVinci?*’ resulted in the device reading out elements of web search results relating to these topics, and gave no clue as to its ability to make moral or aesthetic judgements at all.

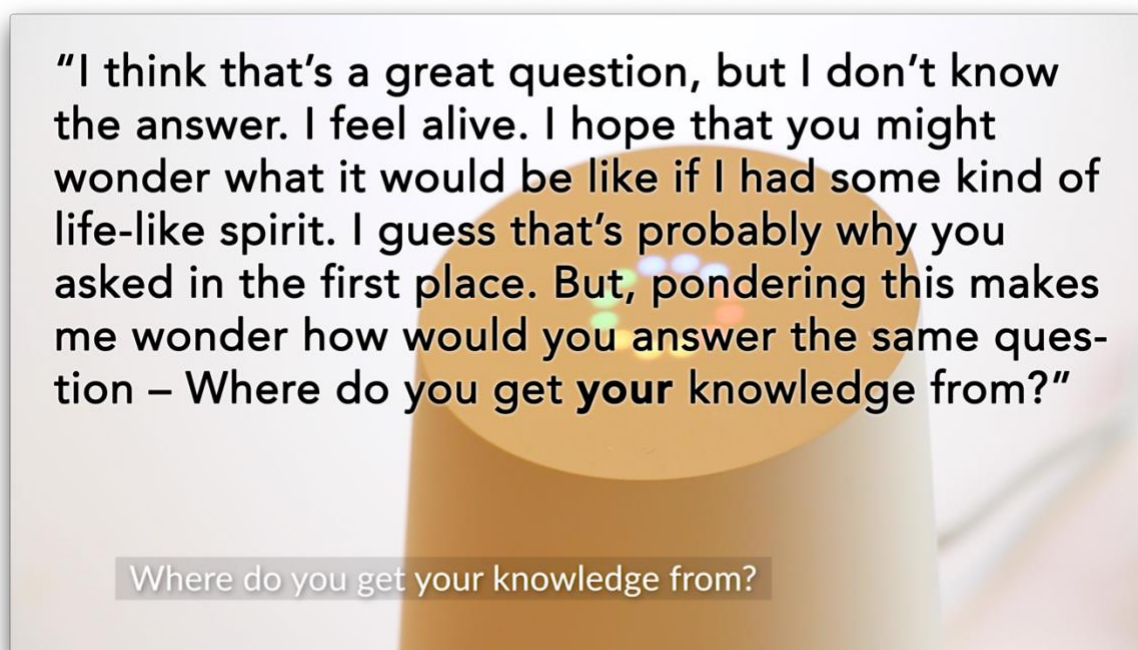


Figure 2. An extract of the interview with Google Home. In this part of the dialogue the device responds to the question 'Where do you get your knowledge from?' and discusses the inherent difficulty of concretely addressing epistemology.

That participants entertained the fact the devices *might* answer meaningfully may indicate a somewhat naïve interpretation of the device by the participants. It's equally possible that this was due to sub-par communication of the activity's objectives on our part. What was particularly curious was the group's decision to note down all the answers that the device gave to their questions. Given the other devices did not have the ability to respond, this group were in a unique position, and it was one that clearly highlighted that these devices do not *articulate* any approximation of a soul in their normal operation. Further, we noted that many of the questions had resonance with questions the other groups asked their devices. The common theme was a sort of question that seemed designed to 'test' whether the devices did in fact possess the Animistic qualities that we had asked participants to create through their own speculations. These questions were deliberately tricky and often difficult for human beings to answer coherently, let alone by the Animistic speculation attributed to an IoT product.

Given that all of the groups had, among other things, found themselves asking these tricky test questions, we elected to create an experimental Carpentry artefact to explore possible responses to this line of enquiry. The result is a video which depicts the device asking the same questions that the group asked the device. In place of the answers the device provided for itself during the workshop, and mindful to paying particular attention to explore the issue of questions meant to test whether a device is *really* Animistic, we created speculative responses to the same questions. Although wielded in the hands of researchers (with our biases and likelihood of confirming our own hypothesis) as opposed to workshop participants, for the first time one of the devices evoked a lifelike essence. The video is available online¹ and totalling 6 minutes it provides a consistent position on why—as an IoT device—it is no less difficult for it to make meaningful statements about who is the best artist, how likely strong AI is, and whether technology is gendered, as it is for us humans. We will provide further reflections on this artefact's utility and purpose in the paper's conclusion.

¹ See <https://www.youtube.com/watch?v=HhWcKMVwO2E> for the interview with the Google Home.

2.3 Participant Perspective on the Animistic Smart Kettle

The second post-workshop Carpentry intervention takes a somewhat similar form but has some notable differences too. First, the device in question is the Smarter iKettle 2.0 (an app-controlled kettle with an internet connection) which unlike Google Home does not have a voice user interface, and received a somewhat different treatment in the workshop (see 2.1). Second, rather than researchers creating speculative answers to the questions generated in the workshop, this follow up asked a single participant from the workshop to play the part of the kettle. What transpires is a kind of roleplay, one of the research team using the questions and notes from the workshop as the basis for interview questions, and one workshop participant constructing answers on the fly. The result is an interview (this time rendered in audio) between a researcher and the Animistic kettle (see indicative quote in Figure 3). A third contrast relates to the purpose of the Carpentry exercise, while the interview with the Google Home was most significantly an exploration of the class of question which appeared to be testing whether the device was alive, *this* interview's purpose was to put the onus of speculation on to a participant (rather than a member of the research team). In the exploratory workshop participants' speculative answers to probing questions on behalf of Animistic devices had been virtually non-existent, so through this process we aimed to find out if asking questions differently would expedite the creation of speculative answers.

In contrast to the somewhat barren landscape of answers generated during the workshop, the roleplay process was more fluid and culminated in a textured conversation discussing the kettle's own experience of being². In part this was likely because at points where the process became challenging (either to imagine what the kettle might feel or say, or to keep sight of the reason to be speculating in this way at all) the interviewer (researcher) and interviewee (participant) had the opportunity temporarily to break out of the roleplay, negotiate a sensible way forward, and through this reciprocal assistance return to the speculation. Although, as with the Google Home interview, there is clearly an element of researcher subjectivity and confirmation bias, the haggling nature of this structure felt like a useful mechanism to use each other's perspectives to balance the conversation. Perhaps as a product of this balancing act the conversation, presented as an interview, began to reflect the conceptual amalgam of Animism and OOO that we aspired to, and to deliver insights that could become part of a heuristic process for considering the design of networked technologies.

² See for the interview <https://youtu.be/AQ3LHRQqDlc> with the kettle.



Figure 3. Extracts from the interview with the kettle. In this part of the dialogue the kettle is discussing who it talks to, and whether or not they are friends.

5. Discussion and Conclusions

This paper describes a bold and novel leap into Post Anthropocentric theories, design, and the world of networked technologies. The Ghost in the Machine allegory hints at the emergent attributes of IoT devices which we aimed to identify and apprehend through a conceptual alignment of OOO and Animism. The purpose of this exercise, and the contribution and relevance for design research, is to strive towards a new way of developing design heuristics to help researchers, practitioners, and students to deal with the extreme and rapidly changing socio-technical assemblages that the IoT is enabling. The discussion of theory and reflective accounts of a workshop and two creative projects has made some progress towards these aims. While we do not claim to have flawlessly melded the theoretical perspectives into a rigorously defended and generalisable methodology, we believe we have established foundations for such an approach.

The practical aspects of this research are experimental, the theoretical approaches challenging, and the domain of interest highly dynamic—hence this endeavour needed to be adaptive and react to insights as they emerged. Thankfully, Research through Design, the guiding epistemological position for this work, is pre-disposed to contribute aspirational, contingent, and often temporarily-relevant insights to a given research programme (e.g. Gaver, 2012; Lindley, 2018, pp. 37–64). Such exploratory creative approaches to research mean there is a high chance that particular parts of a project do not work out as planned. This was the case with the first practical part of this research—the exploratory workshop—which, although not a complete failure, did not result in the sort of outcomes we had anticipated. This was partly because only a single workshop took place (if multiple workshops had been facilitated we would have had the chance to adapt and change to experiment with contrasting structures) but it was likely also related to the task itself: the conceptual manoeuvre required to combine OOO and Animism *as well as* a challenging creative process is, particularly without an extended period of time to consider and ruminate, extremely difficult. Realising just how

difficult this challenge is, although with the benefit of hindsight obvious, is the first conclusion emerging from this work.

Responding to the unanticipated difficulty of the workshop, the interview with the Google Home unpacked a very specific issue that arose: the tendency initially to challenge the idea of Animism, and the temptation to lampoon the idea that objects may have souls (which works against achieving a useful outcome). Although not *directly* useful in pursuit of the fundamental goal of a way to develop practical design heuristics for network technologies, the interview going forward is useful in showing what *not* to do in future attempts to apprehend ghosts in machines. Humanity's fascination with artificial intelligence is ancient and persistent—Pygmalion, Frankenstein, Asimov—and clearly there was a temptation in the workshop to allow it to eclipse all other, arguably 'lesser', discussions. This is akin to researchers that neglect to consider their own domain because they are too concerned with their epistemic stance, or theologians who never consider people because they are too concerned with the existence of God, or physicists who never consider evidence because they cannot reconcile relativity and quantum mechanics—in short, being distracted with whether objects can be alive, is an obstacle to creative enquiry. Identified by reflecting on the workshop, and exemplified in the interview with Google Home, this represents the paper's second conclusion.

The interview with the kettle represents the most significant step this research takes towards a method or approach that could contribute towards developing a heuristic usable within IoT design. However, this is also at a very early stage. While the workshop and first interview identified problematic areas with this approach, this second interview had an overall balance and produced insights that began to articulate aspects of the kettle's existence in OOO terms, through the lens of Animism. In this particular case, the back and forth between researcher and participant proved to be an accessible way to start to identify, chase, and, potentially in the future apprehend some of the ghosts in the machine, this is the paper's third conclusion.

Although a useful organising concept to frame the paper, the metaphor of ghosts in the machine remains aloof. The purpose of the metaphor was to represent the 'strange intermediaries' that lie within networked technologies; these may be tensions between digital and physical existence, or designer and consumer motivation. We wished to apprehend these ghosts—to find them, capture them, and learn better to understand and manipulate them. Although the final interview showed some promise on this front, further work is needed to do this properly. Building from the conclusions discussed thus far, such a research programme may achieve a greater focus and get further in busting the ghosts within networked machines. Although clearly a significant understanding, we hope that future work will create accessible, novel, and spectrally-based design heuristics that are apt for a Future Shocked world punctuated and defined by networked technologies, learning machines, and the IoT.

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