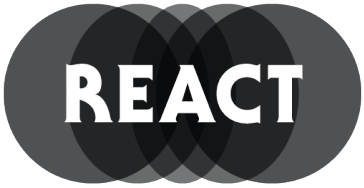


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# Working Paper:
# The Arts and Humanities in the Internet of Things

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The Internet of Things (IoT) will be greatly enhanced by contributions from the researchers in the Arts and Humanities. This is a key finding of our research into REACT Objects Sandbox, a three-month R&D process comprising six cross-sector collaborative projects exploring the future of internet-connected objects. In what follows, this paper outlines the many ways in which Arts and Humanities input can drive the creation of a broader, richly enabling and more adaptive products and services in the IoT. We suggest that supporting this kind of work will require renewed efforts to forge and sustainable cultures of development between diverse sectors, and involve a deeper exploration of the collaborative and educational practices best suited to supporting such cross-sector work.

# 1. Introduction

## About this paper

REACT was established in 2011 and funds collaborations between Arts and Humanities researchers and creative companies to produce innovative prototype products and services. In March 2014, REACT launched Objects Sandbox, a three month R&D process that supported six collaborative projects in exploring the future of the Internet of Things (IoT). The IoT paradigm speaks to the pervasive presence of internet-connected objects in the environment that can interact with each other to support new forms of connectivity between data, objects and people. The Sandbox focused in particular on the role these new networked devices might play in shaping how people encounter, experience, and interact with the world. This paper reports on a research process we instigated into how intellectual approaches common to arts and humanities disciplines can shape the conception and creation of internet-connected objects.

## About this research

In the paper, we argue for a new approach to understanding the IoT, one underpinned by a deeper reflection and analysis of our relationship with objects and the lived, social and cultural realities they support. We show that for an emerging IoT to fulfil its potential, perspectives not just from technology, business and governance, but also from the arts and humanities must be drawn into the wider conversation. Through these diverse voices, a broader, richly enabling and more adaptive IoT lies ahead.

To make this argument, the research explored the following questions:

- What is a suitable conceptual model for understanding the IoT?
- Where can a productive interaction emerge through an engagement with the arts and humanities?
- What do we learn from such interactions, and how can they be encouraged in the future?

A broad approach was taken to gather data, consisting of unstructured observation and informal conversation during Sandbox workshop events, and a total of fourteen semi-structured interviews. These interviews lasted between one to one and a half hours and were conducted with individuals or small groups drawn from the project teams. Wide-ranging in nature, the conversations addressed a number of core themes including: project design, personal and professional motivations, collaborative processes, and thoughts on the shape and future of the IoT.

## Core Findings

We found that the projects commissioned by REACT for the Objects Sandbox reveal the extent to which diverse arts and humanities perspectives can drive a broader, more encompassing IoT through stimulating the development of new forms of networked object. We have found that this occurs in four key ways.

1) by providing comprehensive understanding around the aesthetic, historical, cultural and social contexts in which networked objects can operate

2) by revealing the wider scope of possible networked devices that can be conceived, and the distinctive ways in which they can network people, objects and data

3) by expanding notions of what 'user experience' in the IoT might be, so opening up new roles for networked objects in relation to more complex interactive, social and cultural activities, those through which we apprehend and articulate the conditions of our lives

4) by exposing the breadth, impact and interconnection of valuing practices that can shape the creation of networked objects, practices that extend beyond the money economy to encompass education, innovation, well-being and creative citizenship

## Structure of the paper

To make our argument, we'll first outline what we mean by the Internet of Things, and articulate a way of understanding the field of research into connected objects as an 'ecosystem'. We suggest a framework for exploring how different ideas feed into this ecosystem. We then describe the projects that comprised Objects Sandbox. In the section 4 we apply our framework to these projects, and show how the arts and humanities specifically have contributed to the outcomes of these collaborations. We conclude with some recommendations for the future of collaborative R&D in the IoT.

## 2. Rethinking the Internet of Things

The term "Internet of Things" was coined by Kevin Ashton in the late 1990s during his research at MIT's AutoID lab. This research explored how radio-frequency identification (RFiD) chips might help Proctor & Gamble track commercial supply chains. Reflecting on his initial vision of the IoT, Ashton writes:

> "If we had computers that knew everything there was to know about things – using data they gathered without any help from us – we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best. We need to empower computers with their own means of gathering information, so they can see, hear and smell the world for themselves, in all its random glory. RFID and sensor technology enable computers to observe, identify and understand the world – without the limitations of human-entered data." (Ashton 2009)

Technological advances are now giving rise to an unparalleled capacity to network objects of all kinds. The introduction of Internet Protocol version 6 (IPV6) now means communications addresses can be assigned to billions of devices, wireless radio chips are now cheaper and smaller than ever, mobile data coverage has improved considerably, and improvements in battery technology (and solar recharging) means devices are gaining greater autonomy (Lopez Research 2013 p. 2). Cisco's Internet of Things Group have predicted that there will be over 50 billion connected devices by 2020 (Evans 2012 p. 3).

With these advances, comes an expansion of the IoT beyond Ashton's initial vision. Now, the capabilities to measure, track and shape both human and physical processes is emerging through networked devices that find place at work, at home, in school and elsewhere. In moving towards a state of ubiquity, networked devices are becoming objects bound into our lives just as any other. Understanding the opportunities and challenges in how an emerging IoT will both shape and be shaped by those who make and use it is a task that requires the attention of diverse, cross-sector collaboration.

### Conceptual Approaches to the IoT

Two dominant perspectives on the emerging IoT can currently be discerned, which we have termed Stream 1, and Stream 2. Although these two streams present with many different features, they should be understood as operating simultaneously, and to express points of convergence and overlap.

*Stream 1 Internet of Things*

The first, and dominant, vision bares the strongest resemblance to Ashton's earlier work. We can think of this as "a reactive framework of ideas and thought that sees IoT as a layer of digital connectivity on top of existing infrastructure and things. This position sees IoT as a manageable set of convergent developments on infrastructure, services, applications and governance tools." (von Kranenburg & Bassi 2012 p. 1).

IoT services developed in stream 1 can be broadly understood as focusing on the collection, collation and analysis of data. Focussing on mass markets, a layer of data is applied to recognizable objects such as TVs, mobile phones, and wearable devices including watches and wrist bands. Target application areas include Smart Cities, Smart Car and mobility, Smart Home and assisted living, Smart Industries, Public safety, Energy & environmental protection, Agriculture and Tourism (Vermesan 2013 p. 1). Brought together under a common, global infrastructure that seamlessly connects people, objects and data, the 'Internet of everything' emerges (Evans 2012).

A strong case has been built in support of Stream 1 IoT from the perspective of business, research and governance. The argument made is that the IoT will support better services, enable savings and a smarter use of resources (Vermesan 2013 pp. ix-x). To these ends, core challenges faced concern issues around device

identification, privacy and security, and semantic interoperability (allowing the exchange of information between devices and across services) (ibid pp. 2-3).

*Stream 2 Internet of Things*

The second stream offers a bottom-up rather than a top-down perspective on the value of networked objects. It can be seen as a "…proactive [rather than reactive] framework of ideas and thought that sees IoT as a severely disruptive convergence that is unmanageable with current tools, as it will change the notion of what data and what noise is from the supply chain on to 'apps'." (von Kranenburg & Bassi 2012 p. 1)

A key ambition behind Stream 2 IoT is to imaginatively disrupt, re-compose and playfully augment those patterns of interaction we express within our physical and social surroundings. An interest emerges in novel networked objects that might support the many individual ways in which people organise and give meaning to their lives. With a focus on creating special interactive encounters with physical and social environment, networked devices are understood not as objects with a digital layer added, but as new types of object in their own right.

Stream 2 IoT is largely supported by work from academic labs, artistic research groups, independent creative agencies, hacker collectives, maker communities and artists. Key pressures faced include how simple, readily available technologies can be used to better enable the exploration of human interaction rather than the technological and legislative basis for a global IoT infrastructure.

## *A Role for The Arts and Humanities in the Internet of Things?*

In the IoT, networked devices emerge as a site of convergence for diverse sector interests, including the arts and humanities. With the human-centred IoT focus of the Objects Sandbox, the wider Human Computer Interaction (HCI) community serves as a useful indicator of how arts and humanities perspectives are beginning to impact this area of work.

HCI research is widely believed to be entering its third wave, having re-oriented from an interest in optimizing the fit between engineering and human factors in interaction design to focus on the social connotations, uses, values and implications of technology (Harrison, Tatar & Stengers 2007). At a foundational level, there has been an emerging interest in the study of interpretive processes around objects (Nadin 2001), interaction aesthetics and technology-as-experience (McCarthy & Wright 2007). Against this background, humanities research is supporting an awareness of the cultural, social and historical operation of emerging technologies, driving a shift from product-centred towards ecologies-based thinking (e.g. Forlizzi 2007). Finally, the strong tradition of critical practices in the humanities is offering new scholarly forms such as interaction criticism, aimed at promoting, for example, positive social change and improvements in the quality of human life (Bardzell et al 2012).

These moves towards a deeper understanding of the role of technology find resonance in many contemporary artistic movements, including new media arts and artistic research practices. As Justin McKeown has written in connection with the future of an artistic engagement with emergent technologies: "What makes art valuable is its ability to apprehend the conditions of our lives and articulate them in such a manner that they become tangible as propositions and questions to be inhabited" (McKeown 2014 p. 11). Contemporary artistic practices can offer new means through which technology can be used to encounter our social and physical environments, to address topics such as memory and self-reflection, storytelling and co-creation, alternative and possible futures.

This reflects the changing landscape of cross-sector work in which such perspectives are increasingly playing a part (Hughes et al., 2011). Such cross-sector activities reveal where the incorporation of diverse perspectives might be fruitful, show how collaborative outputs can impact multiple layers of sector activity, can open up perceived sector boundaries to discussion, and can change the very conditions within which collaboration is

possible. As we turn to the IoT and its areas of impact, the need to make sense of, support and expand such collaborative efforts becomes paramount.

## *The Internet of Things as Ecosystem*

As networked devices move towards ubiquity, this common space in which different IoT streams operate – and within which other conceptions of the IoT exist and will arise – requires more attention. In 2011, Innovate UK and Research Councils UK collaborated on an interdisciplinary R&D roadmapping activity to identify the priorities for research and innovation in the IoT (Tafazolli et al., 2012). Six core themes cutting across multiple disciplines and sectors emerged: Governance, Business, People, Trust, Data and Devices and Connectivity. Important topics were raised around accountability, ethics, and the empowerment of users as both subject to, and shapers of, networked devices operating in diverse interactive contexts.

These core themes define a range of concerns for which perspectives from the arts and humanities will be play an important role. It affirms that although research into IoT enabling technologies, desirable applications and viable marketplaces will be important, so to is the depth of reflection and analysis we bring to bear on how objects enable our lived, social and cultural realities. Whilst disciplinary research into individual themes will be critical, considerable work is also needed to better understand the IoT as a *common space* for developments across themes. The value of theorizing a common IoT space in this way is to better enable a wide range of actors (whether individuals, maker collectives, companies or governments) to actively contribute towards shaping and contesting the emergence of the IoT, to determine what the IoT should be.

In this paper, we think of this common space as the *IoT ecosystem* where networked devices should be understood as part of larger, dynamic and adaptive networks of data, objects, people, institutions and practices. Far from endorsing a predestined trajectory for the IoT, it emphasises how networked devices will both shape and be shaped over time by the diverse environments – technological, social and cultural – within its influence. It emphasises that the conversations we have now will impact what the IoT will become. With a view towards creating an adaptive IoT capable of responding to Life's processes of renewal and change, the ecosystem perspective directs attention to identifying where opportunities in knowledge exchange across sectors can emerge, and the collaborative practices best suited to supporting such work.

## *A framework for the IoT ecosystem*

Towards these ends, we have developed a model that attempts to capture the breadth of the IoT ecosystem from the human-centred, interactive perspective of the Objects Sandbox projects. We've conceptualised this framework as comprising of four nested layers, each earlier layer contributing to the structure and operation of the next:

1. *Object Layer*: the point of human encounter with a networked object, i.e. concerned with the interactive properties of the object itself.
2. *Knowledge Layer*: how networked objects influence or underlie the construction of 'ways of knowing' about lived environments. This may be, for example, through the acquisition of information or an engagement in storytelling mediated by the object.
3. *Identity Layer*: how those 'ways of knowing' enabled by networked objects shape an understanding of our own personal concerns and interests. This may be, for example, through encouraging self reflection, or promoting behavioural change.
4. *Community Layer*: how the action of networked objects – through the operation of the previous three layers – exerts social, collective, and institutional effects.

Our research has identified four core domains of interest amongst Sandbox collaborators that find expression within, or impact, the four layers of the framework. These are:

1. *Expertise Domain*: addressing those areas of expertise in a collaborative project (disciplinary, practice-led and so on) critical in shaping the development of a networked object.
2. *Output Domain*: addressing the form that networked objects take and the additional physical/digital components that both support, and arise from, their operation.
3. *User Engagement Domain*: addressing the nature of user engagement that arises through interaction with a given networked object.
4. *Value Domain*: addressing the valuing practices at play in the creation and operation of a networked object.

The IoT ecosystem model developed gives access to a matrix of different properties, actions and influences of networked devices within the IoT ecosystem; this provides a framework for addressing the impact of arts and humanities influences in project development amongst the Sandbox cohort. The projects developed and their analysis through the IoT ecosystem model will now be addressed in more detail.

## 3. Objects Sandbox

The REACT Objects Sandbox was a producer-led, three-month process of workshop, showcase and feedback events through which six project teams were supported in developing an innovative prototype networked object. Project teams varied in size from three to five members, and drew from a wide range of commercial, scholarly and practice-led backgrounds, including academics, researchers, technologists, designers and independent artists. The projects were:

- *Curpanion*: a personalised curatorial device that brings life to museum taxidermy exhibits through activating audio recordings and unlocking online content. This small, hand-held object operates through RFID technology and activates exhibits when docked at a dedicated plinth.

- *Reflector*: a communal object for engaging with stories and historical artefacts related to the transatlantic slave trade. Containing both miniaturised image and receipt printers, the device structures the presentation of materials for classroom discussion.

- *Fans on Foot*: Wearable jewellery to guide cult TV and film fans to locations from their favourite show. Built around a commercially available smartwatch, the device uses an online, location-based exploration service to alert users when passing designated filming locations.

- *Breathing Stone:* a hand-held object that senses and reduces stress by generating music from heart rate data. An aesthetically simple device, the Breathing Stone measures physiological information through skin contact. Generated music is played through a speaker contained within the object.

- *In Touch*: a pair of hand-held devices that enable people in different locations to share stories through haptic interaction. The 'pebbles' map a stroke or squeeze in one onto the other through vibration, enabling direct communication.

- *The God Article*: a technology-enabled reproduction of an ancient Turkish instrument (the Ney) supporting innovative research and teaching practices. This 3-D printed instrument enables fingering and breath patterns to be detected, digitized and visualized in real-time for analysis and observation.

## 4. Findings

### *The Expertise Domain: Building Something Together*

Objects Sandbox projects reveal that arts and humanities perspectives – whether disciplinary or practice-led in nature – can be widely applicable in the conception and development of new types of networked object. This expertise can drive a broadening of the IoT paradigm beyond the two streams described, through providing detailed understanding of the aesthetic, historical, cultural and social qualities of "objects in action". This broadening occurs through the provision of richer perspectives on currently emerging markets (such as quantified-self, communication, and data-delivery), but also through enabling access to new markets around cultural, social, educational and research activities. This impact can be revealed in more detail through the IoT ecosystem perspective:

*Object Layer*: Arts and humanities expertise proved essential in understanding the material and expressive nature of objects addressed in Sandbox projects. In exploring, for example, slave-trade-era funeral artefacts, forms of taxidermy display, musical instrument manufacture or Fandom paraphernalia, we are reminded how expansive, and wrought, the world of "things" really is.

*Knowledge Layer*: Further, such expertise captured how objects are bound into cultural and social activities, those revealing the world around us. Whether exposing a difficult past, uncovering our relationship with the natural world or opening up traditions of musical practice, such expertise critically underscored the development of new networked devices in the Sandbox process.

*Identity Layer*: Building on such expertise, arts and humanities perspectives were able to address how the form and usage of objects can support the exploration of personal interests, concerns and acts of self-knowledge. Themes addressed in the Sandbox cohort included how networked devices might alter agency in traditional forms of cultural practice, enable personal growth and learning, or promote mental health and wellbeing strategies.

*Community Layer*: Finally, arts and humanities perspectives could make sense of the diverse community-based and institutional structures central to the creation of useful networked devices. Whether handling museums and their collections, addressing affected communities and educational programs, or the ethics of global health monitoring, understanding the interests, pressures and sensitivities of target groups was essential for envisaging new markets for such devices.

Making sense of the conditions under which the diverse perspectives present in the Sandbox find voice within a mixed collaborative team is necessary if best practices in cross-sector work are to be developed. Although project participants largely played roles shaped by their areas of expertise, the breadth of that understanding opened up multiple avenues for cross-sector creativity. Firstly, a majority of Sandbox participants considered themselves as working in cross-disciplinary areas: whilst the expertise of design practitioners often reflected origins in arts and humanities subjects outside of formal design training, the majority of arts and humanities participants were committed to work blurring boundaries between scholarly, artistic, commercial and/or lived practices.

> "[Having described the background of the company's founders in graphic design, theatre, film and animation] …[Designer 1] has got her own artistic practice; [Designer 2], there's nothing he can't make with code… and [Designer 3] has awesome design skills and creative skills and is very good at conceiving of wider user experiences. It's by no accident that they're all together on this." [Designer 4]

> "Geography is a very, very interdisciplinary field, so within this department we go from the hard sciences right the way through to somebody like me, who is much more arts and humanities based….I try to be a practitioner as much as a scholar. I really do see cultural geography as a practice, and as a

> way of curating stories about human-environment relations. I think that's a nice way of thinking about it, and a nice way of thinking about my practice, in particular." [Academic 1]

Secondly, project participants were often on the search for new ideas and inspiration: with sensitivities towards the arts and humanities, participating design agencies were keen to explore beyond their normal commitments. Similarly, artists and academics showed a strong interest in exploring the potential of commercial and design practices for their own work/research.

> "I suppose we are equally stimulated by things like social trends as we are [by] new technologies, and we often meld those things together. We are constantly curious and attracted by news stories of things that are happening, that we might put into an arts and humanities space. We are equally stimulated by both and looking in both directions." [Designer 7]

> "We're very strong, as archaeologists, in realizing that we're digging people's pasts up, and therefore we have to be connected with the local community. Again, internet enabled ways of doing that is absolutely natural to us, through Facebook, and blogs, and websites, and then also things like TV and radio, and all the other things that go with it... But social media and web material, web presence, is absolutely what we do, because we realise we have a responsibility to people's past."[Academic 3]

Thirdly, whilst many participants could lay claim to a wealth of disciplinary and practice-based expertise, each found their own way to best draw on their available resources: project participants might turn to rigorous disciplinary practices or more experimental cross-disciplinary expertise as required.

> "I think there is an element of us just doing our normal stuff that we can apply to it [the project]… The value of being involved in the Sandbox project is for these other influences to disrupt the way we might just do things. Equally the collaboration with […] is about being receptive to those other influences, which we are." [Designer 6]

> [when asked to contribute his technical expertise to the project] "I'm very deliberately not doing that, I'm just making music, really, and then letting them worry about it, that's not completely true, but there's a certain amount of truth to that. Yes, just keeping my music hat firmly on, and not my technical hat." [Academic 8]

The consequence of these synergies and overlaps in expertise was that whilst clear input from specific disciplines could be identified in every project, many ideas emerged through co-creative processes. Discussions, for example, around ethics and technology, objects and storytelling, memory and reflection, emerged in a variety forms where contributions from single collaborators or disciplinary traditions were not attributable. These observations reveal an intricate picture of professional, disciplinary and lived practices through which such perspectives can come to the surface. Understanding such conditions of collaboration will play an important role when advocating for arts and humanities involvement in future work in technology and innovation.

### *The Output Domain: Creating Contextual Objects*

The Sandbox process revealed how the expertise presented in Domain 1 could open up new possibilities for the form internet-connected devices might take, and the networks of data, objects and people they might support. Critical points of innovation were seen in each project, developments necessitated by the input of arts and humanities perspectives. Taken together, it is the richer understanding of these output possibilities within the IoT paradigm that will enable a broader, more flexible and dynamic IoT to be created. This impact can be revealed in more detail through the IoT ecosystem perspective. Through its layered structure, the wider form of a networked objects – constituting physical, data and network structures – can be appreciated and their patterns of effect discerned.

*Object Layer*: The Sandbox cohort called for the creation of an extraordinarily diverse range of networked devices. Whilst some projects explored the creation of techno-cultural objects that were highly original in form (such as the In Touch hand-held haptic pebbles), others created novel networked devices that were to imitate known objects (the stylised watch-like device of Fans on Foot), or fully reproduce an existing culturally-significant object in a new form (such as the Turkish Ney). In a number of projects, devices consisted of multiple technical and non-technical elements.

*Knowledge Layer*: The devices developed opened up new ways of structuring access, or creating exposure, to information. This could be seen in the new approaches adopted in connecting physical and virtual content bound to artefacts (Reflector and Curpanion projects), and also through driving new means of quantifying, representing and communicating user behaviour (such as Breathing Stone's musical interface for heart rate data).

*Identity Layer*: To these ends, networked devices were designed to open up innovative ways of placing the user at the centre of a given operation. For example, the personalised Curpanion object offers many on-line and off-line functions that require a user to serve a curatorial and collecting role. In the Reflector project, it is the intense physicality of exposing and manipulating diverse materials that places the user closer to that of an archaeologist.

*Community Layer*: Finally, the cohort revealed the extent to which the design and operation of networked devices can support diverse community-level effects and models of exclusivity and accessibility. In the In Touch project, for example, a private intranet system was proposed for supporting intimate paired interactions. In comparison, the open-source approach adopted by the God Article team would enable diverse and emerging communities to build their own networked objects, supporting individual and group activities (publicly and privately, online and offline).

In considering the range of networked objects created through a collaboration with the arts and humanities, our research has revealed three core areas of innovation relative to the two IoT streams discussed: Firstly, that the diversity of arts and humanities interests addressed require a broader approach to the design of networked devices. This is achieved either through incorporating standard technologies (RFID, mini printers, smart watches) into novel systems, or through driving the development of highly innovative technological and interface solutions. Secondly, that such interests compel the design of networked objects that extend beyond the simple record-collect-analyse model common to stream 1 IoT. This can be seen in the creation of devices that set and alter the conditions for their own usage over time, opening up devices to more intricate and complex operations. Consider, for example, the self-reflexive and intellectual spaces generated in the Reflector project, each new fragment of data impacting how earlier, and future, materials might be understood. Finally, that such interests open up new avenues for future innovation: the technology developed for measuring patterns of breathing and manual dexterity in the God Article project could find novel commercial application in the medical and sport sectors; the combination of haptic stimulation and storytelling to generate a rich sensory engagement explored in the In Touch project could be developed into novel therapeutic approaches for Alzheimer's disease or dementia.

## *The User Engagement Domain: Making Experiences Possible*

Envisioning how someone might encounter, use and feel about a networked device is a critical part of any IoT project development. User experience – or 'UX' – is the term given to describe these interactions and the many ways we design for them. Whilst traditional approaches to UX aim at maximising the ease and clarity of product interaction, models emerged in the Objects Sandbox that probed deeper into the impact devices might have on the quality of lived experience. Further, the influence of arts and humanities perspectives was seen to question how networked objects might generate multiple possible, rather than specifically-curated, futures for the user. These facets of UX are more intangible, harder to design, and difficult to quantify. Taken together, it is this wider understanding of what UX might mean within the IoT that could open up new roles for networked objects in complex interactive, social and cultural activities, those that support us in apprehending and articulating the conditions of our lives. The IoT ecosystem model helps reveal this broader scope and

depth of UX as shaped by the expertise discussed in Domain 1 and expressed through the outputs addressed in Domain 2.

*Object Layer*: Arts and humanities perspectives played an important role in opening up ideas of user experience around object encounter. For example: The Reflector device enables a more playful, participatory engagement with traditionally-safeguarded cultural artefacts; the fandom device of Fans On Foot explores the ambiguous ground between objects intended to be seen and understood by some, but not others; the In Touch haptic device opens up new forms of sensory engagement in distance-storytelling.

*Knowledge Layer*: These perspectives on object encounter impact the means for testing and exploring patterns of experience for the user. Projects asked whether networked devices might enable new forms of bodily-awareness beyond mere quantification (Breathing Stone and God Article), open up new trajectories in acts of learning through introducing elements of hypothesis-testing and serendipity (Curpanion, Reflector), or support creative storytelling through the creation of original, personalized patterns of communication (In Touch).

*Identity Layer*: In investigating rich forms of interaction with networked devices, many projects sought to intensify user agency beyond standard UX measures, opening up the user's own role to further questioning. The cohort offered user-directed acts of curation that can grow beyond institutional practices (Curpanion), user-initiated discussion around hard histories beyond traditional learning models (Reflector), user-centred responsibility in acts of self-directed wellbeing (Breathing Stone).

*Community Layer*: These appraisals of UX also considered community-level effects. Whilst the Breathing Stone object is designed to actively remove the user from social life, intense social engagement has been built into the form and operation of the Reflector device. Whilst the Curpanion project aims to strengthen the bond between a user and a particular institution/collection, the God Article platform opens up new and variable community spaces for shared learning and engagement.

In a number of cases, strong synergies emerged between the arts and humanities partners and design professionals around the exploration of new forms of UX. For example, in the Reflector project, the desire to expose students to a surprise-laden process of uncovering material elements – so mirroring the archaeological process – found resonance with the design agency's interest in building serendipity and moments of delight into UX design. Similarly, in the God Article project, a shared interest across the project team emerged in the centrality and largely intangible nature of the individual aesthetic experience. A graphical presentation layer for the project's data was proposed that could be easily modified and replaced to uniquely express each musician's understanding of their own performance practice. These observations again reveal an openness across sectors that allows new perspectives on user experience to emerge. Our research suggests that in industries where models of UX may have become overly codified and/or limited by commercial pressures, contact with new agendas and insights from the wider arts and humanities may be highly valuable.

> "I think that was partly why I wanted to do something a bit different as well [with Objects Sandbox]. When I moved away from product design into interaction design, it was because I had an interest in why people use products, and the effects that product use has on people… Actually so much product use just is taken for granted, and the way that products … don't invade your life but they become part of your life and they shape how you behave as an individual, as a community and socially. I think commercially you don't get a chance to do that at all, that's not part of the question. That's not part of your remit whatsoever…. It's very rarely that people stop to think because they're difficult questions to ask" [Designer 5].

## *The Value Domain: What's it Worth?*

Whilst economic value is a dominant factor in the development of any commercially-viable networked device, other valuing practices will be intrinsic to devices that are to operate in, or shape, complex experiential, cultural and social realities. Valuing practices related to governance, security, energy, health, culture and wellbeing have already been introduced for the two IoT streams. The current research shows how diverse

value practices arising within collaborative projects such as Objects Sandbox can find rich expression in the production of networked devices. The IoT ecosystem model can help reveal such practices.

*Object Layer*: Across the cohort, arts and humanities perspectives both recognised and emphasised the specialness of objects in our world of interactions. Great importance was attached to how objects can immerse users in a particular physical, sensory and attentive world, and eliminate the constant partial attention associated with multi-function, screen-based devices.

*Knowledge Layer*: From this basis, valuing practices emerged around different types of knowledge gained through device usage, and the path taken to reach such understanding. In Curpanion, generating a process of learning around natural histories that could be fun, relatable, exciting and informative was primarily important. For the Reflector team, opening up learning strategies that captured the hard work of interpreting data, and testing, rejecting and regenerating hypotheses was as significant as the material understood.

*Identity Layer*: In this process, core values around how a user should be changed by their experience with networked devices could be identified. Some issues addressed included the personal gains of supporting mindfulness and emotional resilience to stressors in our daily encounters (Breathing Stone), the value of developing critical thinking skills and effortful, directed activity in educational practices (Reflector and Curpanion), and the enriching nature of 'making and thinking' (God Article).

*Community Layer*: Together, such valuing practices revealed wider social concerns and interests. These included supporting and invigorating cultural traditions and institutional practices, the value of exposing and exploring stories around our natural, social world, and, finally, the public value of empowering individuals in a socially-minded way.

Making sense of how different value systems are created, articulated and circulated is necessary if a fuller understanding is to be gained of what value might mean in the IoT.[1] In Reflector, for example, we see the emergence of a hypothetical value cycle centred on developing creative and innovative citizens through learning-experiences in the classroom that are engaging and thought-provoking. Here, value finds articulation in concepts of creativity and innovation; value is created through the future-application of these skills in wider society, legitimizing – longer term – these innovative practices. Similarly, in the Breathing Stone project, we see the emergence of a hypothetical value cycle centred on wellbeing. Repeated successful encounters with the Breathing Stone may promote effective mindfulness and enable emotional resilience. Here, value finds articulation in wellbeing, value is created through a greater capacity to cope with one's environment.

Within the Cohort, it becomes clear that multiple forms of value constellation are possible, a fundamental property of the IoT ecosystem as it operates in the world. Taken together, the influence of arts and humanities perspectives could be seen in the creation of projects with considerable public and personal value, but also more effective mainstream commercial products. Indeed, if these Sandbox projects are to succeed commercially, it would be in no small part due to their shaping through the non-commercial valuing practices described.

[1] This works applies ideas from the model of multiple value economies by Bachmann and colleagues (Bachmann et al 2012).

## 5. The Role of the Arts and Humanities in an Emergent IoT

The impact of arts and humanities perspectives, as revealed across the IoT ecosystem model, reveals the value of a broad, collaborative approach to the development of networked devices. In missing the opportunity to explore the diverse and alternative IoT futures that such work enables, a narrower conception of it will emerge, one that may fall short of its wider potential and accountability. Amongst Sandbox participants, three core areas of concern were raised for the trajectory of the IoT that is currently dominant.

Firstly, issue was taken with an IoT development driven only through commercial interests. That arts and humanities input in collaboration with design agencies can support the creation of networked devices that offer public (cultural and social) value is clear from the current work. Such insights highlight the important role networked devices can play beyond purely commercial considerations. As one researcher observed:

> "We have to understand that if we take the broader concept of public value as a way into this [issue of the creative economy], understanding ideas about, for example, conservation, sustainability, responsible living; all those kinds of things are part of this discourse. They don't necessarily have money attached to them." … "But that's why we have to, as I say – going back to this key word 'public value' – understand that what we really want to do is create public value through internet connected technology, that isn't necessarily economic, but in terms of making Britain a better place in terms of its education, the understanding and appreciation of its landscape, its heritage." [Academic 1]

Further, in the focus on real-world encounter and experience that characterised the Sandbox projects, a widespread ambivalence emerged towards practices that push for new means to gather, quantify and analyse data solely on their own merits without a critical approach as to their uses, benefits and wider consequences. The capacity to apply technological scrutiny to the world is only part of what the IoT can offer, and only part of what we should be desiring of it. There are other ways of knowing, experiencing and describing the world beyond this that are themselves compatible with – indeed enabled by – networked objects operating as part of the IoT. As one researcher observed on the topic of pushing technological boundaries:

> "At the end of the day, I think we have the moral obligation … just because there's computer science – just because we can – doesn't necessarily mean we should." … "It is the human aspect that we want to make a difference. To me, like I said before, just because I can doesn't necessarily mean I should, unless it makes a difference." [Academic 2]

Finally, in honing-in on the quality of lived experience that an IoT platform might enable, many participants asked how networked devices could be used to enrich or intensify our interaction with the world, rather than simplify or smooth-over existing tedious or time-consuming actions. There was scepticism towards an IoT in which the surroundings learn to classify and respond to a user's behavioural patterns through continuous monitoring and sensing (driving adjustments in room temperature, background music and so on…). One researcher commented that:

> "The problem I have with it is that the more obstacles you remove between the human and the interaction with media and with benefit, the more obstacles you remove between the human and the value they're trying to seek or the value that we're trying to give them, the more opportunity you remove for that value to be fully useful, to be fully assimilated and understood. That understanding actually, I think, is where emotional resilience really lies. You don't become emotionally resilient by constantly having things handed to you. You become emotionally resilient by failing and by interacting with things in muddy, dirty, uncomfortable, awkward ways that then eventually become seamless and easy and yours." [Academic 3]

These three core concerns – the dominance of commercial interests, penetration of networked devices and data acquisition into all areas of life, and device/infrastructure concealment – are all key drivers behind a

ubiquitous, seamless and largely hidden IoT. Whilst a case for such an IoT has been built on macroeconomic arguments concerning health, energy, communication, governance, security and so on, it also has its critics. Concern has been voiced about an IoT where human agency is reduced to database traffic, where we become less-able to decide on when and how to engage with the physical and social environment around us, where individual identity and social life become moulded into the standards and categories of embedded technical systems (Ratto 2007 p. 25; Kranenburg 2008 p. 18; Nadin 2013). In this frame, we can see a constraint on the expression of human complexity that may limit the possible futures we are capable of expressing. We see a route towards less dialogue, less innovation, less commercial opportunities, less adaptability and less sustainability (Kranenburg 2008 p.18). In the Objects Sandbox, strong examples can be found for how networked devices can pull the user back into an interaction with the world rather then eliminate them from it. We see the user shaped as an active agent, one that is responsible, accountability and deeply involved in opening up their own possible future trajectories.

## 6. Recommendations

The Internet of Things may radically change our understanding of how data, objects, people and institutions can become bound into dynamic networks. It challenges our understanding of how networked objects might operate in a complex world, capable of both transforming, and being transformed, by it. This working paper has discussed an ecosystem perspective for capturing the scope and depth of the IoT as revealed through the REACT Objects Sandbox. It has endeavoured to demonstrate the critical role the arts and humanities can play in broadening our understanding of the potential scope and applicability of a human-centred IoT platform. Indeed, this is the 'healthy state' of the IoT ecosystem, one in which diverse perspectives are dynamically engaged to drive cultural innovation that targets "an enhancement of the qualities of shared life from which all forms of health and wealth can flow" (Bachmann et al 2012 pp. 8-9): Creative industry as a driver of national economy but also a better society.

The ecosystem perspective reminds us that the shape of the IoT that emerges will be fashioned through the discussions we have now. How then can we advocate for a richer collaborative process across sectors and disciplines in the shaping of the IoT?

*Cultures of Development*: New cultures of development between technologists, design agencies, industry and the arts and humanities will be needed to bring forward a broader, more encompassing vision of the IoT – a sentiment strongly echoed amongst Objects Sandbox participants. Opening up practices to new influences, challenges and cooperation, a foundation for best practices might be laid for discussing and contesting the IoT ecosystem. Forging and sustaining such alignments across sectors will drive the building of networks amongst fragmented creative talent that can support multiple adaptive generators of IoT-focused activities.

*Collaborative Engagement*: Collaborative frameworks must be able to both mobilize and support the plurality of opinions at play in the IoT ecosystem. Previous research suggests that the REACT Sandbox process and the PM studio environment have considerable success in helping diverse cross-sector practitioners locate and explore mutual interests and values with long term potential (Bachmann et al 2012; Moreton & Dovey 2013; Dovey et al 2014). There was general agreement that this was also the case in the Objects Sandbox. Where project teams did encounter difficulties, it was often apparent that more had to be done in opening up and structuring encounters across cultural, disciplinary and professional boundaries.

*Education:* Principally, the challenges faced in developing the IoT – themselves a microcosm of much larger issues at play around technology and society – will require educational approaches that can equip future designers, researchers and scholars with both specialised disciplinary knowledge, but also a wider appreciation of other disciplines and fields of research. This was considered to be of paramount importance within the university sector, the design sector, and also more widely for connecting professional activities to other 'ways of knowing' and 'ways of making' outside of company or university activities.

Taken together, these three areas addressing the conditions of cross-sector work find resonance with the wider recommendations of the Innovate UK and RCUK roadmapping exercise (Tafazolli et al 2012).

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